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# THE PERFORMANCE EVALUATION AND EMISSION STUDY OF COMPRESSION IGNITION ENGINE OPERATING WITH BLENDS OF ANIMAL FAT AND PALM OIL BASED BIODIESELS

**SHAIK KHADAR BASHA[1], SATISHKUMAR[1] & NITIN D KAMITKAR[2]**

[1]*Department of Mechanical Engineering, QIS College of Engineering and Technology, Ongole*

[2]*Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Guntur, Andhra Pradesh, India*

***ABSTRACT***

***Depletion of origin and anguish of health issues due to emissions by petroleum discharge triggered to take necessary steps to avoid adverse effects on forthcoming generation. In view of this tremendous work is being done to diminish dependence on fossil fuels by biodiesel which are ecofriendly. In this research work an investigation of biodiesel blends with diesel at different ratios will be done. Blends of pig fat biodiesel and palm biodiesel are prepared with different proportions of diesel. The composition abbreviated as APD with prefixing different percentage which indicates the quantity of biodiesel. From results recorded, it has noticed that 20% APD can be directly used without any modification in the engine. Performance results and emission results are acceptable for 20% blend which is in range with diesel. HC and CO emissions are less for all blends but $CO_2$ and $NO_x$ emissions increases with blend ratios. 20% APD sample emission data is well compromised with diesel at all loads. Hence it can be said that 20% APD can be a potential sample that can be used directly in engine without modification.***

***KEYWORDS: Health, Biodiesel, Fossil Fuel & Ecofriendly***

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Original Article

## INTRODUCTION

Acceleration in demand of energy and conversion techniques have impacted healthy environment. Fossil sources which contributed major shares in power generation and transportation have kept on indicating their exhaustion. Consequently it is essential to sort out with the problem through alternative source which is ecofriendly and can be renewable. Plant and animal extractions which have the ability to react chemically like fossil fuels exhibited nearby results. Pure biodiesel of juliflora has shown 3% of lesser brake thermal efficiency with same CO, HC emissions but $NO_x$ emission is slight higher than diesel [1]. Investigations of palm biodiesel blends indicated standard properties which are essential for an engine with optimum performance. Each 10% of palm biodiesel blend has reduced 1.42% of energy content which has restricted the blend quantity up to 30% [2]. Combination of different biodiesels with diesel in terms of 10% and 20% has accelerated NOx emissions whereas CO, HC and $CO_2$ are in range with diesel [3]. Biodiesel prepared from animal fat has shown higher fuel consumption with higher cylinder gas pressure and increases $CO_2$, $NO_x$ emissions [4]. Blends of palm kernel oil with automotive gas oil at different ratios have shown decrease in CO emissions up to 30% and whereas no significant change in $NO_x$ emission has noticed at 10% biodiesel blend with 90% diesel [5]. Direct addition of seed powder to control

emissions have reduced $NO_x$ emissions without changing the performance at full load [6]. In Brazil it is mandated to blend standard 4% of biodiesel with diesel on which Tukey test results have shown decrease in $CO_2$ at higher load [7]. In test carried on engine with 20% blends of Jatropha, moringa oil and palm oil, it is observed palm oil has better performance and lower CO, HC emissions [8]. Transesterification process of waste animal fat oil cost effective compared to plant seed oil extraction which can easily compete with petroleum based fuels in developing country but quality and contamination of animal fat must require proper purification which can be done by deep eutectic solvents [9, 10]. Test on engine with animal fat based biodiesel blend have shown reduced unburned hydrocarbons by 45% whereas output is lowered by 9% [11]. From literature it has noticed that biodiesel and their blend at different ratios have assured sufficient results which can directly influenced authors to investigate engine with blends of animal fat and palm oil based biodiesel blends at different loads.

## MATERIALS AND METHODS

### Preparation of Samples and Characterization

Samples are prepared by mixing animal fat (lard) biodiesel, palm oil biodiesel and diesel at different ratios as mentioned in table 1. Quantity of the oils measured accurately and stirred manually such that a homogeneous sample is prepared.

**Table 1: Blend Composition**

| Sample | Diesel (in %) | Animal Fat Biodiesel (in %) | Palm oil Biodiesel ( in %) |
|---|---|---|---|
| Diesel | 100 | 0 | 0 |
| 20 APD | 80 | 10 | 10 |
| 40 APD | 60 | 20 | 20 |
| 60 APD | 40 | 30 | 30 |
| 80 APD | 20 | 40 | 40 |
| 100 APD | 0 | 50 | 50 |

Prepared samples are tested and characterized according to ASTM standards; blends at different ratios of animal fat biodiesel and palm oil biodiesel with diesel have shown acceptable results to run the engine without modification. Different properties are tabulated in table 2.

**Table 2: Blend Properties**

| Fuel | Flash Point ($^0$C) | Fire Point ($^0$C) | Density (kg/m$^3$) | Calorific Value (kJ/kg) |
|---|---|---|---|---|
| Diesel | 56 | 62 | 827 | 43000 |
| 20 APD | 66 | 74 | 835.6 | 41854 |
| 40 APD | 74 | 85 | 844.2 | 40708 |
| 60 APD | 80 | 97 | 852.8 | 39562 |
| 80 APD | 110 | 128 | 861.4 | 38416 |
| 100 APD | 162 | 178 | 870 | 37270 |

### Engine Test Rig

Tests were conducted in a well-established thermal lab of KONERU LAKSHAMAIAH EDUCATION FOUNDATION (Deemed to be University); Guntur District A. P. Single Cylinder water cooled, naturally aspirated with computerized data interpreter setup directly coupled to a swinging field dynamometer. Direct injection engine without modification with specification mentioned in table 3 has used. Line diagram of setup and engine setup is shown in figure 1

and figure 2 respectively.

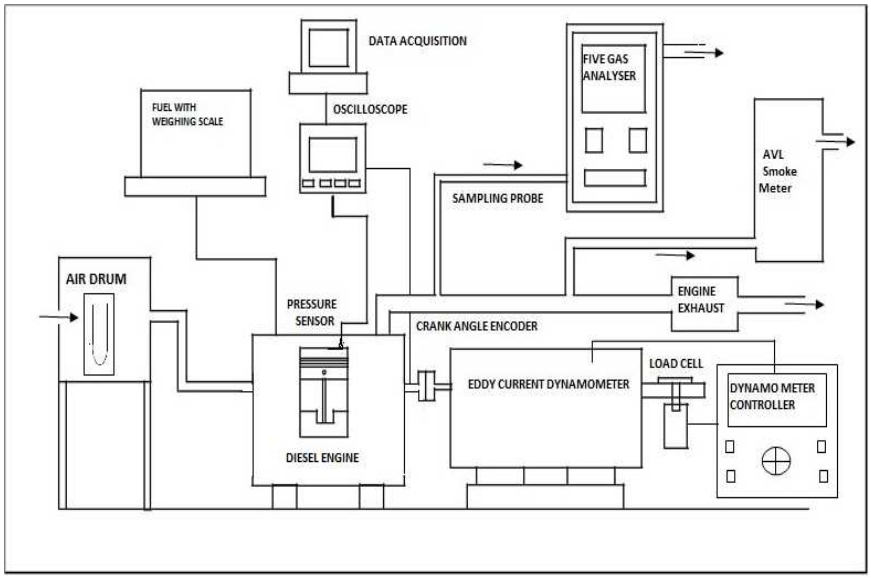


**Figure 1: Line Diagram of Engine Setup**

**Figure 2: Engine Setup**

**Table 3: Engine Specification**

| Parameter | Specification |
|---|---|
| Engine Type | 4-Stroke, single cylinder diesel engine. |
| Make | Kirloskar |
| Maximum Brake Power | 4.7 kW |
| Rated speed | 1500RPM |
| Bore (D) | 80mm |
| Stroke (L) | 110mm |
| Compression Ratio | 16:1 |
| Loading | Electrical loading by varying Voltage |
| Dynamometer | swinging field dynamometer |
| Cooling | water cooling |
| Starting | By hand crank |

Five gas analyzer of crypton company (Figure 3) was used to measure the exhaust compositions of blends at different loads. For every fuel change the fuel line was purged out of the residual fuel. The engine was made to run under full load for at least 30 min to stabilize on new fuel conditions. Test-rig is provided with necessary equipment and instruments for recording the air flow, fuel flow, temperatures and load measurements.


**Figure 3: Five Gas Analyzer**

Error analysis of instruments is an important task of research which justifies the accuracy of the data collected. Holman procedure was used to calculate an average error in the instruments which is found to be ±2.1%

## RESULTS AND DISCUSSIONS

### Performance Analysis

Performance properties of duel bio-fuel methyl esters are discussed. Results of the experiments in the form of brake power, brake thermal efficiency, specific fuel consumption at different load conditions for various blends of duel bio-fuel methyl esters compared with the petroleum diesel in the form of color plots.

### Brake Thermal Efficiency

The brake thermal efficiency (BTE) variations with load for various blends of methyl esters are shown in figure 4. From plot it is observed that the BTE is slightly lower than the diesel for duel bio-fuel methyl ester and its blends. BTE is dependent of calorific value which decelerates as blend ratio increases. For CI engine brake thermal efficiency gradually increases with increase in bp. From the plot it is observed that brake thermal efficiency is low at low values of bp and is increases with bp for all blends of fuel. For a blend of 20% the brake thermal efficiency is high at low bp values when compared with other blends of fuel and is very close to diesel at high values of bp. Pure APD fuel sample results are high at lower load and decreases with increase in load.

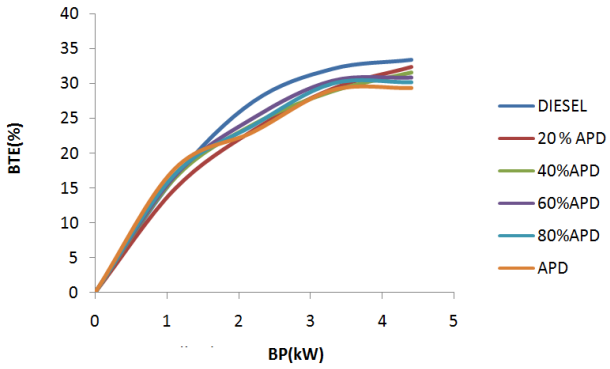


**Figure 4: Brake Thermal Efficiency versus BP**

### Specific Fuel Consumption

Fuel consumption is the rate at which engine spends the fuel for particular output or load. Figure 5 shows different fuel consumption rates for same engine under different blends. Fuel consumption is inversely proportional to the load. From plot it is seen that diesel has lowest fuel consumption rate at all loads. 20% blend has shown nearer characteristics at

moderated load however again it increases at full load. At no load 20 % blend has highest fuel consumption among all. 100 % blend has highest FC at full load. Lower calorific value and higher viscosity of biodiesel has boosted fuel consumption compared to diesel.

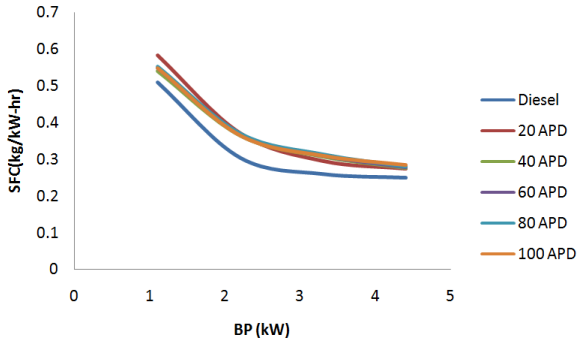


**Figure 5: Specific Fuel Consumption versus BP**

## EMISSION ANALYSIS

As from literature it is noticed that drastic variation of exhaust composition with biodiesel blends or pure biodiesel. Hence it is essential to investigate and debate on exhaust of engine operating with blends and pure diesel.

### CO Emission

The comparison of variation of carbon monoxide (CO) emissions with break power for diesel, with different blends of duel bio-fuel methyl esters are shown in figure 6. From plot 6 it is observed that CO decreases with increasing load for all the blends of duel bio-fuel methyl esters. If percentage of blends of duel bio-fuel methyl esters increases, CO reduces. The concentration of CO decreases with the increase in percentage of APD in the fuel. This may be attributed to the presence of O2 in APD sample, which provides sufficient oxygen for the conversion of carbon monoxide (CO) to carbon dioxide (CO2). It can be observed that blending 20% APD with diesel results in a slight reduction in CO emissions when compared to that of diesel. 40% blend has shown higher CO emissions at lower load but gives lower results at peak load.

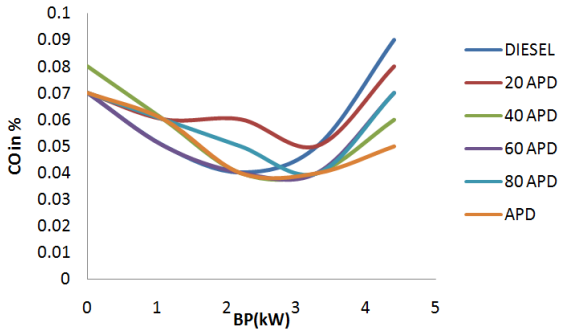


**Figure 6: Carbon Monoxide versus BP**

### HC Emission

The comparison of hydrocarbons (HC) emissions for diesel and APD blends presented Figure 7. From plot it is observed that hydro carbon (HC) increases with increasing load for all the blends of duel bio-fuel methyl esters. If percentage of blends of duel bio-fuel methyl esters increases, HC reduces. The hydrocarbon emissions are inversely

proportional to the percentage of APD in the fuel blend. A significant difference between APD and diesel operation can be inferred. The diesel oil operation showed the highest concentrations of HC in the exhaust at all loads. Since APD is an oxygenated fuel, it improves the combustion efficiency and hence reduces the concentration of hydrocarbon emissions (HC) in the engine exhaust. Blending 20% APD with diesel greatly reduces HC emissions especially at rated load condition.

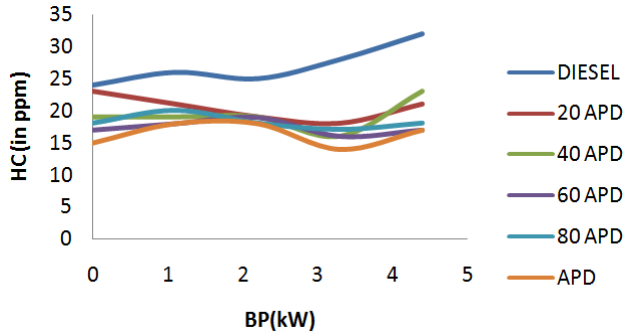


**Figure 7: Unburned Hydrocarbons versus BP**

### $CO_2$ Emission

The comparison of CO2 emissions for diesel, neat APD and blends are shown in figure 8. From plot it is observed that CO2 increases with increasing load for all the blends of duel bio-fuel methyl esters. If percentage of blends of duel bio-fuel methyl esters increases, CO2 increases. The CO2 emissions are directly proportional to the percentage of APD in the fuel blend. Since APD is an oxygenated fuel, it improves the combustion efficiency and hence increases the concentration of CO2 in the exhaust.

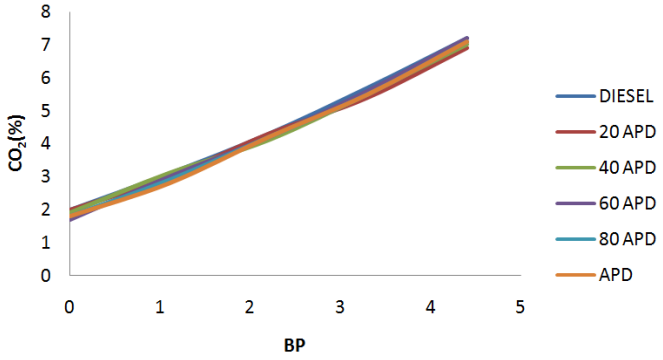


**Figure 8: Carbon dioxide versus BP**

### $NO_x$ Emission

The comparison of NOx emissions for diesel, neat APD and blends are shown in figure 9. From plot it is observed thatNOx increases with increasing load for all the blends of duel bio-fuel methyl esters. If percentage of blends of duel bio-fuel methyl esters increases, NOx increases.. The NOx increase for APD may be associated with the oxygen content of the APD, since the fuel oxygen may augment in supplying additional oxygen for NOx formation. Moreover, the higher value of peak cylinder temperature for APD when compared to diesel may be another reason that might explain the increase in NOX formation.

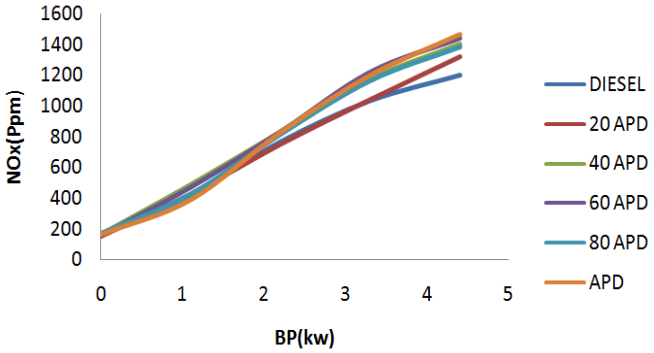


**Figure 9: Oxides of Nitrogen versus BP**

## CONCLUSIONS

Experiment has been done by blending biodiesel in different volumes with diesel. The engine performance parameters like brake power, brake thermal efficiency and specific fuel consumption indicated thermal efficiency, brake thermal efficiency etc., have been observed for various blends at different loads. It is clear that, at 20% blending of biodiesel the engine performance is found to be very appreciable. At this blending trial particularly at full load and half load conditions the specific fuel consumption and brake thermal efficiency are very closer to the values obtained without blending. HC and CO emissions are less for all blends but $CO_2$ and $NO_x$ emissions increases with blend ratios. From the detailed data and plots it is summarized that direct utilization of biodiesel in diesel engine is not acceptable but blend 0f 20% is suitable at all loads. Increase in blend ratio required suitable modification in engine which is not economical. Hence it is concluded that 20% of APD blend can be used directly without any modification in the engine.

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